SCIENCE TEST

35 Minutes—40 Questions

Directions: This test contains seven passages, each followed by several questions. After reading each passage, select the best answer to each question and fill in the corresponding oval on your Answer Grid. You may refer to the passages while answering the questions. You may NOT use a calculator on this test.

Passage I

The table below contains some physical properties of common optical materials. The refractive index of a material is a measure of the amount by which light is bent upon entering the material. The transmittance range is the range of wavelengths over which the material is transparent.

Table 1

Physical Properties of Optical Materials				
Material	Refractive index for light of 0.589 μm	Transmittance range (μm)	Useful range for prisms (μm)	Chemical resistance
Lithium fluoride	1.39	0.12–6	2.7–5.5	Poor
Calcium fluoride	1.43	0.12–12	5–9.4	Good
Sodium chloride	1.54	0.3–17	8–16	Poor
Quartz	1.54	0.20–3.3	0.20–2.7	Excellent
Potassium bromide	1.56	0.3–29	15–28	Poor
Flint glass*	1.66	0.35–2.2	0.35–2	Excellent
Cesium iodide	1.79	0.3–70	15–55	Poor

*Flint glass is lead oxide doped quartz.

1. According to the table, which material(s) will transmit light at 25 μm?
   A. Potassium bromide only
   B. Potassium bromide and cesium iodide
   C. Lithium fluoride and cesium iodide
   D. Lithium fluoride and flint glass

2. A scientist hypothesizes that any material with poor chemical resistance would have a transmittance range wider than 10 μm. The properties of which of the following materials contradicts this hypothesis?
   F. Lithium fluoride
   G. Flint glass
   H. Cesium iodide
   J. Quartz

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3. When light travels from one medium to another, total internal reflection can occur if the first medium has a higher refractive index than the second. Total internal reflection could occur if light were traveling from:

   A. lithium fluoride to flint glass.
   B. potassium bromide to cesium iodide.
   C. quartz to potassium bromide.
   D. flint glass to calcium fluoride.

4. Based on the information in the table, how is the transmittance range related to the useful prism range?

   F. The transmittance range is always narrower than the useful prism range.
   G. The transmittance range is narrower than or equal to the useful prism range.
   H. The transmittance range increases as the useful prism range decreases.
   J. The transmittance range is wider than and includes within it the useful prism range.

5. The addition of lead oxide to pure quartz has the effect of:

   A. decreasing the transmittance range and the refractive index.
   B. decreasing the transmittance range and increasing the refractive index.
   C. increasing the transmittance range and the useful prism range.
   D. increasing the transmittance range and decreasing the useful prism range.

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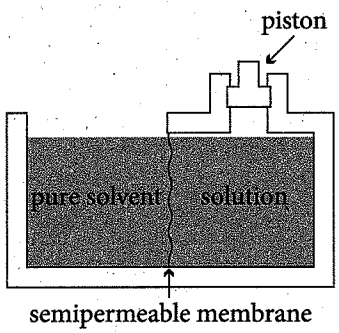
Passage II

Osmosis is the diffusion of a solvent (often water) across a semipermeable membrane from the side of the membrane with a lower concentration of dissolved material to the side with a higher concentration of dissolved material. The result of osmosis is an equilibrium—an even distribution—on both sides of the membrane. In order to prevent osmosis, external pressure must be applied to the side with the higher concentration of dissolved material. *Osmotic pressure* is the external pressure required to prevent osmosis. The apparatus shown below was used to measure osmotic pressure in the following experiments.



EXPERIMENT 1

Aqueous (water-based) solutions containing different concentrations of sucrose were placed in the closed side of the apparatus. The open side was filled with water. The sucrose solutions also contained a blue dye that binds to the sucrose. The osmotic pressure created by the piston was measured for each solution at various temperatures. The results are given in Table 1.

Table 1

Concentration of sucrose solution (mol/L)	Temperature K	Osmotic pressure (atm)
1.00	298.0	24.47
0.50	298.0	12.23
0.10	298.0	2.45
0.05	298.0	1.22
1.00	348.0	28.57
0.50	348.0	14.29
0.10	348.0	2.86
0.05	348.0	1.43

EXPERIMENT 2

Sucrose solutions of four different organic solvents were investigated in the same manner as in Experiment 1 with all trials at 298 K. The results are shown in Table 2.

Table 2

Solvent	Concentration of sucrose solution (mol/L)	Osmotic pressure (atm)
Ethanol	0.50	12.23
Ethanol	0.10	2.45
Acetone	0.50	12.23
Acetone	0.10	2.45
Diethyl ether	0.50	12.23
Diethyl ether	0.10	2.45
Methanol	0.50	12.23
Methanol	0.10	2.45

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6. According to the experimental results, osmotic pressure is dependent upon the:
   F. solvent and temperature only.
   G. solvent and concentration only.
   H. temperature and concentration only.
   J. solvent, temperature, and concentration.

7. According to Experiment 2, if methanol was used as a solvent, what pressure must be applied to a 0.5 mol/L solution of sucrose at 298 K to prevent osmosis?
   A. 1.23 atm
   B. 2.45 atm
   C. 12.23 atm
   D. 24.46 atm

8. A 0.10 mol/L aqueous sucrose solution is separated from an equal volume of pure water by a semipermeable membrane. If the solution is at a pressure of 1 atm and a temperature of 298 K:
   F. water will diffuse across the semipermeable membrane from the sucrose solution side to the pure water side.
   G. water will diffuse across the semipermeable membrane from the pure water side to the sucrose solution side.
   H. water will not diffuse across the semipermeable membrane.
   J. water will diffuse across the semipermeable membrane, but the direction of diffusion cannot be determined.

9. In Experiment 1, the scientists investigated the effect of:
   A. solvent and concentration on osmotic pressure.
   B. volume and temperature on osmotic pressure.
   C. concentration and temperature on osmotic pressure.
   D. temperature on atmospheric pressure.

10. Which of the following conclusions can be drawn from the experimental results?
    I. Osmotic pressure is independent of the solvent used.
    II. Osmotic pressure is only dependent upon the temperature of the system.
    III. Osmosis occurs only when the osmotic pressure is exceeded.
    F. I only
    G. III only
    H. I and II only
    J. I and III only

11. What was the most likely purpose of the dye placed in the sucrose solutions in Experiments 1 and 2?
    A. The dye showed when osmosis was completed.
    B. The dye showed the presence of ions in the solutions.
    C. The dye was used to make the experiment more colorful.
    D. The dye was used to make the onset of osmosis visible.

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Passage III

A chemist investigating the influence of molecular weight and structure on the boiling point (transition from liquid to gaseous state) of different compounds recorded the data in the tables below. Two types of compounds were investigated: organic carbon compounds (shown in Table 1) and inorganic compounds (shown in Table 2).

Table 1

Straight-Chain Hydrocarbons		
Molecular formula	**Molar weight* (g/mol)**	**Boiling point (°C)**
CH_4	16	−162
C_2H_6	30	−88
C_3H_8	44	−42
C_4H_{10}	58	0
C_5H_{12}	72	36
C_8H_{18}	114	126
$C_{20}H_{42}$	282	345

*Molar weight is the weight of one mole, or an *Avogadro's Number* of molecules ($\approx 6 \times 10^{23}$), in grams.

Table 2

Other Substances (Polar and Non-Polar)		
Molecular formula	**Molar weight (g/mol)**	**Boiling point (°C)**
N_2*	28	−196
SiH_4*	32	−112
GeH_4*	77	−90
Br_2*	160	59
CO**	28	−192
PH_3**	34	−85
AsH_3**	78	−55
ICl**	162	97

**Non-Polar:* molecule's charge is evenly distributed.

***Polar:* molecule's negative and positive charges are partially separated.

12. Which of the following straight-chain hydrocarbons would NOT be a gas at room temperature?

F. C_2H_6
G. C_3H_8
H. C_4H_{10}
J. C_5H_{12}

13. Which of the following conclusions is supported by the observed results?

I. Boiling point varies directly with molecular weight.
II. Boiling point varies inversely with molecular weight.
III. Boiling point is affected by molecular structure.

A. I only
B. II only
C. I and III only
D. II and III only

14. Based on the data in Table 1, the boiling point of the straight-chain hydrocarbon C_6H_{14} (molecular weight 86 g/mol) is most likely:

F. 30°C.
G. 70°C.
H. 130°C.
J. impossible to predict.

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15. Based on the data in Table 2, as molecular weight increases, the difference between the boiling points of polar and non-polar substances of similar molecular weight:

    A. increases.
    B. decreases.
    C. remains constant.
    D. varies randomly.

16. A polar substance with a boiling point of 0°C is likely to have a molar weight closest to which of the following:

    F. 58
    G. 80
    H. 108
    J. 132

Passage IV

A series of experiments was performed to study the environmental factors affecting the size and number of leaves on the *Cycas* plant.

EXPERIMENT 1

Five groups of 25 *Cycas* seedlings, all from 2–3 cm tall, were allowed to grow for 3 months, each group at a different humidity level. All of the groups were kept at 75°F and received 9 hours of sunlight a day. The average leaf lengths, widths, and densities are given in Table 1.

Table 1

% Humidity	Average length (cm)	Average width (cm)	Average density* (leaves/cm)
15	5.6	1.6	0.13
35	7.1	1.8	0.25
55	9.8	2.0	0.56
75	14.6	2.6	0.61
95	7.5	1.7	0.52

*Number of leaves per 1 cm of plant stalk

EXPERIMENT 2

Five new groups of 25 seedlings, all from 2–3 cm tall, were allowed to grow for 3 months, each group receiving different amounts of sunlight at a constant humidity of 55%. All other conditions were the same as in Experiment 1. The results are listed in Table 2.

Table 2

Sunlight (hrs/day)	Average length (cm)	Average width (cm)	Average density* (leaves/cm)
0	5.3	1.5	0.32
3	12.4	2.4	0.59
6	11.2	2.0	0.56
9	8.4	1.8	0.26
12	7.7	1.7	0.19

*Number of leaves per 1 cm of plant stalk

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EXPERIMENT 3

Five new groups of 25 seedlings, all from 2–3 cm tall, were allowed to grow at a constant humidity of 55% for 3 months at different daytime and nighttime temperatures. All other conditions were the same as in Experiment 1. The results are shown in Table 3.

Table 3

Day/night temperature (°F)	Average length (cm)	Average width (cm)	Average density* (leaves/cm)
85/85	6.8	1.5	0.28
85/65	12.3	2.1	0.53
65/85	8.1	1.7	0.33
75/75	7.1	1.9	0.45
65/65	8.3	1.7	0.39

*Number of leaves per 1 cm of plant stalk

17. Which of the following conclusions can be made based on the results of Experiment 2 alone?
    A. The seedlings do not require long daily periods of sunlight to grow.
    B. The average leaf density is independent of the humidity the seedlings receive.
    C. The seedlings need more water at night than during the day.
    D. The average length of the leaves increases as the amount of sunlight increases.

18. Seedlings grown at a 40% humidity level under the same conditions as in Experiment 1 would have average leaf widths closest to:
    F. 1.6 cm.
    G. 1.9 cm.
    H. 2.2 cm.
    J. 2.5 cm.

19. According to the experimental results, under which set of conditions would a *Cycas* seedling be most likely to produce the largest leaves?
    A. 95% humidity and 3 hours of sunlight
    B. 75% humidity and 3 hours of sunlight
    C. 95% humidity and 6 hours of sunlight
    D. 75% humidity and 6 hours of sunlight

20. Which variable remained constant throughout all of the experiments?
    F. The number of seedling groups
    G. The percent of humidity
    H. The daytime temperature
    J. The nighttime temperature

21. It was assumed in the design of the three experiments that all of the *Cycas* seedlings were:
    A. more than 5 cm tall.
    B. equally capable of germinating.
    C. equally capable of producing flowers.
    D. equally capable of further growth.

22. As a continuation of the three experiments listed, it would be most appropriate to next investigate:
    F. how many leaves over 6.0 cm long there are on each plant.
    G. which animals consume *Cycas* seedlings.
    H. how the mineral content of the soil affects the leaf size and density.
    J. what time of year the seedlings have the darkest coloring.

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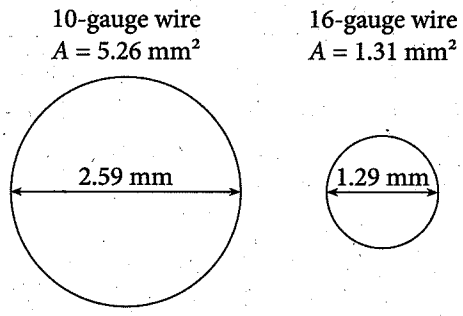
Passage V

The resistance (R) of a conductor is the extent to which it opposes the flow of electricity. Resistance depends not only on the conductor's resistivity (ρ), but also on the conductor's length (L) and cross-sectional area (A). The resistivity of a conductor is a physical property of the material that varies with temperature.

A research team designing a new appliance was researching the best type of wire to use in a particular circuit. The most important consideration was the wire's resistance. The team studied the resistance of wires made from four metals—gold (Au), aluminum (Al), tungsten (W), and iron (Fe). Two lengths and two gauges (diameters) of each type of wire were tested at 20°C. The results are recorded in the following table.



Note: area of circle = πr^2

Table 1

Material	Resistivity (mV–cm)	Length (cm)	Cross-sectional area (mm^2)	Resistance (mV)
Au	2.44	1.0	5.26	46.4
Au	2.44	1.0	1.31	186.0
Au	2.44	2.0	5.26	92.8
Au	2.44	2.0	1.31	372.0
Al	2.83	1.0	5.26	53.8
Al	2.83	1.0	1.31	216.0
Al	2.83	2.0	5.26	107.6
Al	2.83	2.0	1.31	432.0
W	5.51	1.0	5.26	105.0
W	5.51	1.0	1.31	421.0
W	5.51	2.0	5.26	210.0
W	5.51	2.0	1.31	842.0
Fe	10.00	1.0	5.26	190.0
Fe	10.00	1.0	1.31	764.0
Fe	10.00	2.0	5.26	380.0
Fe	10.00	2.0	1.31	1,528.0

23. Of the wires tested, resistance increases for any given material as which parameter is decreased?

A. Length
B. Cross-sectional area
C. Resistivity
D. Gauge

24. Given the data in the table, which of the following best expresses resistance in terms of resistivity (ρ), cross-sectional area (A), and length (L)?

F. $\frac{\rho A}{L}$
G. $\frac{\rho L}{A}$
H. ρAL
J. $\frac{AL}{\rho}$

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25. Which of the following wires would have the highest resistance?

A. A 1-cm aluminum wire with a cross-sectional area of 0.33 mm^2

B. A 2-cm aluminum wire with a cross-sectional area of 0.33 mm^2

C. A 1-cm tungsten wire with a cross-sectional area of 0.33 mm^2

D. A 2-cm tungsten wire with a cross-sectional area of 0.33 mm^2

26. According to the information given, which of the following statements is (are) correct?

I. 10-gauge wire has a larger diameter than 16-gauge wire.

II. Gold has a higher resistivity than tungsten.

III. Aluminum conducts electricity better than iron.

F. I only

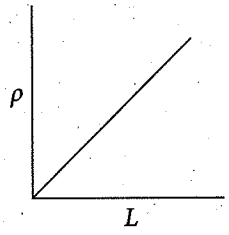
G. II only

H. III only

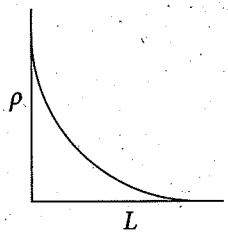
J. I and III only

27. Which of the following graphs best represents the relationship between the resistivity of a tungsten wire and its length?

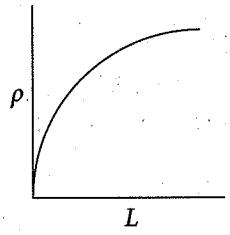
A.



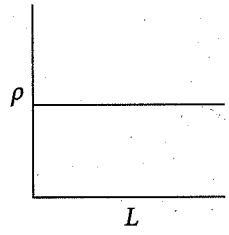
B.



C.



D.



Passage VI

How does evolution occur? Two views are presented below.

SCIENTIST 1

Evolution occurs by natural selection. Random mutations are continually occurring in a species as it propagates. A number of these mutations result in traits that help the species adapt to environmental changes. Because these mutant traits are advantageous, the members of the species who possess them tend to survive and pass on their genes more often than those who do not have these traits. Therefore, the percentage of the population with an advantageous trait increases over time. Long necks evolved in giraffes by natural selection. The ancestors of giraffes had necks of various sizes; however, their average neck length was much shorter than the average neck length of modern-day giraffes. Since the food supply was limited, the individuals with necks on the long range of the spectrum had access to more food (the leaves of trees) and therefore were more likely to survive and pass on their traits than individuals with shorter necks. Therefore, the proportion of the individuals with long necks is slightly greater in each subsequent generation.

SCIENTIST 2

Evolution occurs by the inheritance of acquired characteristics. Characteristics that are acquired by an individual member of a species during its lifetime are passed on to its offspring. Therefore, each generation's traits are partially accounted for by all the changes that occurred in the individuals of the previous generation. This includes changes that occurred as a result of accidents, changes in the environment, overuse of muscles, etc. The evolution of long necks of giraffes is an example. Ancestors of giraffes had short necks and consequently had to stretch their necks to reach the leaves of trees that were their main source of food. This repeated stretching of their necks caused them to elongate slightly. This trait was passed on, so that the individuals of the next generation had slightly longer necks. Each subsequent generation also stretched their necks to feed; therefore, each generation had slightly longer necks than the previous generation.

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28. Both scientists agree that:

F. the environment affects evolution.
G. the individuals of a generation have identical traits.
H. acquired characteristics are inherited.
J. random mutations occur.

29. How would the two hypotheses be affected if it were found that all of the offspring of an individual with a missing leg due to an accident were born with a missing leg?

A. It would support Scientist 1's hypothesis, because it is an example of random mutations occurring within a species.
B. It would refute Scientist 1's hypothesis, because it is an example of random mutations occurring within a species.
C. It would support Scientist 2's hypothesis, because it is an example of an acquired characteristic being passed on to the next generation.
D. It would support Scientist 2's hypothesis, because it is an example of random mutations occurring within a species.

30. Which of the following characteristics can be inherited according to Scientist 2?

I. Fur color
II. Bodily scars resulting from a fight with another animal
III. Poor vision

F. I only
G. II only
H. I and III only
J. I, II, and III

31. Scientist 1 believes that the evolution of the long neck of the giraffe:

A. is an advantageous trait that resulted from overuse of neck muscles over many generations.
B. is an advantageous trait that resulted from a random mutation.
C. is an advantageous trait that resulted from a mutation that occurred in response to a change in the environment.
D. is a disadvantageous trait that resulted from a random mutation.

32. The fundamental point of disagreement between the two scientists is whether:

F. giraffes' ancestors had short necks.
G. evolved traits come from random mutations or from the previous generation.
H. the environment affects the evolution of a species.
J. the extinction of a species could be the result of random mutations.

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33. Suppose evidence was found that suggested that before the discovery of fire, human skin lacked the nerve endings necessary to detect extreme heat. Which of the following pieces of information, if true, would most seriously weaken the hypothesis of Scientist 2?

    A. Human skin is capable of generating nerve endings with new functions during life.
    B. The total number of nerve endings in the skin of a human is determined at birth and remains constant until death.
    C. An excess of nerve endings that are sensitive to extreme heat is a relatively common human mutation.
    D. No evidence exists to suggest that an excess of nerve endings that are sensitive to heat could be acquired through mutation.

34. The average height of a full-grown person today is significantly greater than was the average height of a full-grown person 1,000 years ago. If it was proven that the increase in average height was due only to evolutionary changes, how would Scientist 1 most likely explain this increase?

    F. People genetically prone to growing taller have been more likely to produce offspring over the last 1,000 years.
    G. Over the last 1,000 years, improvements in nutrition and medicine have led to greater average growth over a person's lifetime, and this growth has been passed from one generation to the next.
    H. Increased height is not a trait that can be acquired through mutation.
    J. Measurements of average height were less accurate 1,000 years ago than they are today.

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Passage VII

Bovine spongiform encephalopathy (BSE) is caused by the spread of a misfolded protein that eventually kills infected cattle. BSE is diagnosed postmortem from the diseased cavities that appear in brain tissue and is associated with the use in cattle feed of ground-up meat from scrapie-infected sheep. A series of experiments was performed to determine the mode of transmission of BSE. The results are given in the table below.

EXPERIMENT 1

Sixty healthy cows were divided into two equal groups. Group A's feed included meat from scrapie-free sheep; and Group B's feed included meat from scrapie-infected sheep. Eighteen months later, the two groups were slaughtered and their brains examined for BSE cavities.

EXPERIMENT 2

Researchers injected ground-up sheep brains directly into the brains of two groups of 30 healthy cows. The cows in Group C received brains from scrapie-free sheep. The cows in Group D received brains from scrapie-infected sheep. Eighteen months later, both groups were slaughtered and their brains examined for diseased cavities.

Table 1

Group	Mode of transmission	Scrapie present	Number of cows infected with BSE*
A	feed	no	1
B	feed	yes	12
C	injection	no	0
D	injection	yes	3

*As determined visually by presence/absence of spongiform encephalopathy

35. Which of the following hypotheses was investigated in Experiment 1?

A. The injection of scrapie-infected sheep brains into cows' brains causes BSE.

B. The ingestion of wild grasses causes BSE.

C. The ingestion of scrapie-infected sheep meat causes scrapie.

D. The ingestion of scrapie-infected sheep meat causes BSE.

36. What is the purpose of Experiment 2?

F. To determine whether BSE can be transmitted by injection

G. To determine whether BSE can be transmitted by ingestion

H. To determine whether ingestion or injection is the primary mode of BSE transmission

J. To determine the healthiest diet for cows

37. Which of the following assumptions is made by the researchers in Experiments 1 and 2?

A. Cows do not suffer from scrapie.

B. A year and a half is a sufficient amount of time for BSE to develop in a cow.

C. Cows and sheep suffer from the same diseases.

D. Cows that eat scrapie-free sheep meat will not develop BSE.

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38. A researcher wishes to determine whether BSE can be transmitted through scrapie-infected goats. Which of the following experiments would best test this?

    F. Repeating Experiment 1, using a mixture of sheep and goat meat in Group C's feed

    G. Repeating Experiments 1 and 2, replacing sheep with healthy goats

    H. Repeating Experiments 1 and 2, replacing healthy sheep with healthy goats and scrapie-infected sheep with scrapie-infected goats

    J. Repeating Experiment 2, replacing healthy cows with healthy goats

39. What is the control group in Experiment 1?

    A. Group A

    B. Group B

    C. Group C

    D. Group D

40. Which of the following conclusions is (are) supported by the experiments?

    I. Cows that are exposed to scrapie-infected sheep are more likely to develop BSE than cows that are not.

    II. BSE is only transmitted by eating scrapie-infected sheep meat.

    III. A cow that eats scrapie-infected sheep meat is more likely to develop BSE than a cow that is injected with scrapie-infected sheep brains.

    F. II only

    G. III only

    H. I and III only

    J. II and III only

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS SECTION ONLY. DO NOT TURN TO ANY OTHER SECTION IN THE TEST. STOP